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NEW TERM FOR EFFECT OF TEMPERATURE ON pH_{min} -VALUES IN CARDINAL PARAMETER GROWTH MODELS FOR *LISTERIA MONOCYTOGENES*

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Cardinal parameter models for growth and growth boundary of *L. monocytogenes* (CPM-Lm) are popular, extensively validated and widely used for various foods in the assessment and management of risk. Interestingly, available CPM-Lm includes very different pH_{min} -values from 4.3 to 5.0. This can be due to differences in the mathematical terms used to estimate pH_{min} -values and to strain variability as often suggested. However, the experimental conditions used to estimate pH_{min} -values remain little studied although the minimal pH-values supporting growth is known to depend on other environmental conditions including temperature. Therefore, the objective was to study the influence of temperature on pH_{min} -values of *L. monocytogenes* as used in CPM-Lm.

The combined effect of temperature and pH on maximum specific growth rate (μ_{max}) for eight different *L. monocytogenes* strains were determined experimentally by using Bioscreen C or collected from the literature (287 μ_{max} -values). 16 pH-values from 4.4 to 6.8 and eight temperatures from 5°C to 37°C were studied. At each temperature the pH_{min} -value was estimated by fitting a simple pH_{min} -model (AEM, 63, 2355-2360, 1997). pH_{min} -values decreased from 5.0 at 5°C to 4.3 at 20°C and then increased to 4.7 at 37°C. These changes in pH_{min} -values has major influence on predictions from CPM-Lm, particularly for products with low pH values of less than about 5 and a new pH_{min} -model to describe the influence of temperature on pH_{min} -values in CPM-Lm was developed as shown below.

$$0^{\circ}\text{C} \leq T < T_{ref} \quad pH_{minT} = pH_{min0} - T * \left(\frac{pH_{min0} - pH_{minR}}{T_{ref}} \right)$$

$$T_{ref} < T < 37^{\circ}\text{C} \quad pH_{minT} = pH_{minR} + (T - T_{ref}) * \left(\frac{pH_{min37^{\circ}\text{C}} - pH_{minR}}{37 - T_{ref}} \right)$$

where T is the storage temperature (°C); pH_{minT} the fitted pH_{min} -value at $T^{\circ}\text{C}$; T_{ref} the estimated reference temperature (°C); pH_{min0} and pH_{minR} the fitted pH_{min} -values at 0°C and T_{ref} (°C), respectively.

The fixed pH_{min} -value from an existing CPM-Lm including 12 environmental parameters (IJFM, 141, 137-150, 2010) was substituted by the new pH_{min} -model and the model performance has been evaluated for 33 growth/no growth responses of *L. monocytogenes* in a well characterized food with pH below 5.

Average bias and accuracy factor values were 1.16 and 1.27 for 30 growth curves at constant temperatures. The new pH_{min} -model can estimate the pH_{min} -value for *L. monocytogenes* based on temperature storage conditions and this markedly extend the limit of applicability of the existing CPM-Lm from pH 5.6 to pH 4.4.